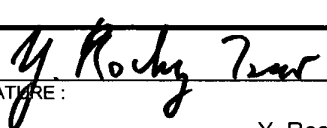


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SUBSTITUTE FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 00537-111004												
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If Known, see 37 CFR 1.5) 09/807087												
INTERNATIONAL APPLICATION NO. PCT/US99/23406	INTERNATIONAL FILING DATE 8 October 1999	PRIORITY DATE CLAIMED 9 October 1998												
TITLE OF INVENTION IONIC MOLECULAR CONJUGATES OF N-ACYLATED DERIVATIVES OF POLY(2-AMINO-2-DEOXY-D-GLUCOSE) AND POLYPEPTIDES														
APPLICANT(S) FOR DO/EO/US Shalaby W. Shalaby, Steven A. Jackson, Francis X. Ignatious, Jacques-Pierre Moreau and Ruth M. Russell														
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:														
1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input type="checkbox"/> This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)). 4. <input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (PCT Article 31). 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)) a. <input checked="" type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> has been communicated by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). 7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> An English language translation of amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). 10. <input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). Items 11 to 16 below concern other documents or information included: 11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 13. <input type="checkbox"/> A FIRST preliminary amendment. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 14. <input type="checkbox"/> A substitute specification. 15. <input type="checkbox"/> A change of power of attorney and/or address letter. 16. <input checked="" type="checkbox"/> Other items or information: <input checked="" type="checkbox"/> Copy of the annexes to the International Preliminary Examination Report <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>														
<table border="1"> <tr> <td colspan="2">CERTIFICATE OF MAILING BY EXPRESS MAIL</td> <td>Express Mail Label No. EL 258935095 US</td> </tr> <tr> <td colspan="3">I hereby certify under 37 CFR §1.10 that this correspondence is being deposited with the United States Postal Service as Express Mail Post Office to Addressee with sufficient postage on the date indicated below and is addressed to the Commissioner for Patents, Washington, D.C. 20231.</td> </tr> <tr> <td>April 9, 2001</td> <td>Samantha Bell</td> <td>Samantha Bell</td> </tr> <tr> <td>Date of Deposit</td> <td>Signature</td> <td>Typed Name of Person Signing</td> </tr> </table>			CERTIFICATE OF MAILING BY EXPRESS MAIL		Express Mail Label No. EL 258935095 US	I hereby certify under 37 CFR §1.10 that this correspondence is being deposited with the United States Postal Service as Express Mail Post Office to Addressee with sufficient postage on the date indicated below and is addressed to the Commissioner for Patents, Washington, D.C. 20231.			April 9, 2001	Samantha Bell	Samantha Bell	Date of Deposit	Signature	Typed Name of Person Signing
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Date of Deposit	Signature	Typed Name of Person Signing												

U.S. APPLICATION NO. (IF KNOWN) 09/807087		INTERNATIONAL APPLICATION NO. PCT/US99/23406		ATTORNEY'S DOCKET NUMBER 00537-111004	
17. <input checked="" type="checkbox"/> The following fees are submitted: Basic National Fee (37 CFR 1.492(a)(1)-(5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO..... \$1000 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO..... \$710 International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4)..... \$690 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4)..... \$100 <div style="text-align: right;">ENTER APPROPRIATE BASIC FEE AMOUNT =</div>				CALCULATIONS PTO USE ONLY	
				\$860.00	
Surcharge of \$130 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$0.00	
Claims	Number Filed	Number Extra	Rate		
Total Claims	9 - 20 =		x \$18	\$0.00	
Independent Claims	2 - 3 =		x \$80	\$0.00	
MULTIPLE DEPENDENT CLAIMS(S) (if applicable)			+ \$270	\$0.00	
TOTAL OF ABOVE CALCULATIONS =				\$0.00	
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				\$0.00	
SUBTOTAL =				\$0.00	
Processing fee of \$130 for furnishing the English Translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f))				\$0.00	
TOTAL NATIONAL FEE =				\$0.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +				\$0.00	
TOTAL FEES ENCLOSED =				\$860.00	
				Amount to be refunded:	\$
				Charged:	\$
a. <input checked="" type="checkbox"/> A check in the amount of \$860.00 to cover the above fees is enclosed. b. <input type="checkbox"/> Please charge my Deposit Account No. 06-1050 in the amount of \$0.00 to cover the above fees. A duplicate copy of this sheet is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 06-1050. A duplicate copy of this sheet is enclosed. NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status. SEND ALL CORRESPONDENCE TO:					
Y. Rocky Tsao FISH & RICHARDSON P.C. 225 Franklin Street Boston, MA 02110-2804 (617) 542-5070 phone (617) 542-8906 facsimile			<div style="text-align: center;">  SIGNATURE: </div> <div style="text-align: center;"> Y. Rocky Tsao NAME </div> <div style="text-align: center;"> 34,053 REGISTRATION NUMBER </div>		

5 IONIC MOLECULAR CONJUGATES OF N-ACYLATED DERIVATIVES OF POLY(2-AMINO-2-DEOXY-D-GLUCOSE) AND POLYPEPTIDES

Cross Reference to Related Application

This application is a continuation-in-part of copending application, Application No. 08/929,363, filed September 9, 1997, which is a divisional application of Application No. 08/468,947, filed June 6, 1995.

10 Background of the Invention

Polymer drug delivery systems have been developed for the controlled release of pharmaceutical polypeptides. For example, synthetic polyesters such as poly(DL-lactic acid), poly(glycolic acid), poly(lactic-glycolic acid), and poly(ϵ -caprolactone) have been used in the form of microcapsules, films, or rods to release biologically active polypeptides. See e.g., U.S. Patent Nos. 4,767,628 and 4,675,189 and PCT Application No. WO 94/00148.

In addition to the synthetic polymeric chains, natural polymers and their derivatives have been used as components in similar sustained release compositions that dissociate by enzymatic degradation. One example of such natural polymers are those based on chitin, a poly(N-acetylglucosamine). However, since chitin is water insoluble, others have examined solubilizable derivatives which are based primarily on a partially deacetylated chitin, e.g., chitosan. See e.g., Sanford, P.A. et al., Eds., Advances in Chitin & Chitosan (1992). Although chitosan can be found in some fungi, the production of biodegradable chitosan is generally performed synthetically. See Mima, et. al., J. Appl. Polym. Sci. 28:1909-1917 (1983). Synthetic derivatives of chitosan have also been prepared to alter the polymer's *in vivo* biological characteristics. See Muzzarelli, et al., Carbohydrate Res. 207:199-214 (1980).

The use of chitin, as well as chitin derivatives, has been proposed in a number of drug delivery systems. See, e.g., European Patent Application Nos. 486,959, 482,649, 525,813 A1, and 544,000 A1; and U.S. Patent No. 5,271,945.

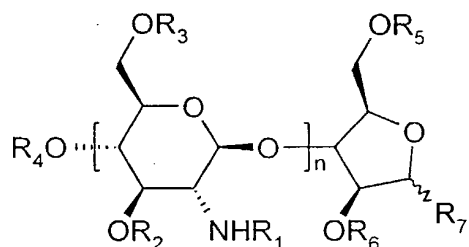
30 Summary of the Invention

In one aspect, the present invention features a copolymer including an N-acylated derivative of poly(2-amino-2-deoxy-D-glucose), wherein between 1 and 50 percent of the free amines of the poly(2-amino-2-deoxy-D-glucose) are acylated with a

first acyl group, the first acyl group is COE_1 where E_1 is selected from the group consisting of C_{3-33} carboxyalkyl, C_{3-33} carboxyalkenyl, C_{7-39} carboxyarylalkyl, and C_{9-39} carboxyarylalkenyl, and between 50 and 99 percent of the free amines of the poly(2-amino-2-deoxy-D-glucose) are acylated with a second acyl group, the second acyl group is COE_2 where E_2 is selected from the group consisting of C_{1-30} alkyl, C_{2-30} alkenyl, C_{6-37} arylalkyl, and C_{8-37} arylalkenyl, provided at least one of the free amines of the derivative is acylated with the first acyl group.

The copolymer preferably has a molecular weight of about 3,000 to 90,000 daltons. In other preferred embodiments, over 90 percent of the free amines of the poly(2-amino-2-deoxy-D-glucose) are acylated with either the first acyl group or the second acyl group. Preferably, between 10 and 30 percent of the free amine of the poly(2-amino-2-deoxy-D-glucose) are acylated with the first acyl group. Some of the free hydroxy groups (e.g., between 1 and 30 percent) of the derivative may be acylated with either the first acyl group or the second acyl group.

In a preferred embodiment, the copolymer is of the formula:



wherein:

R_1 , for each individual repeat unit, is selected from the group consisting of first acyl group, second acyl group, and H;

R_2 , for each individual repeat unit, is selected from the group consisting of first acyl group, second acyl group, and H;

R_3 , for each individual repeat unit, is selected from the group consisting of first acyl group, second acyl group, and H;

R_4 is selected from the group consisting of first acyl group, second acyl group, and H;

R_5 is selected from the group consisting of first acyl group, second acyl group, and H;

R_6 is selected from the group consisting of first acyl group, second acyl group, and H;

R_7 is selected from the group consisting of COH and CH_2OR_8 ;

R_8 is selected from the group consisting of first acyl group, second acyl group, and H;

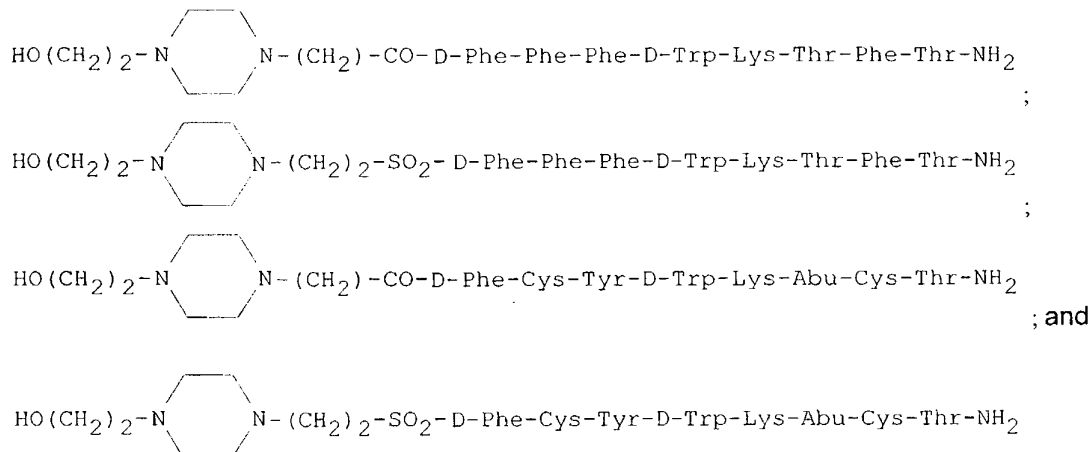
n is between 2 and 200; and

for between 1 and 50 percent of the repeat units, R_1 is first acyl group, and for between 50 and 99 percent of the repeat units, R_1 is second acyl group, provided that for at least one of the repeat units, R_1 is first acyl group.

The terms COE_1 and COE_2 stand for $-\text{C}=\text{O}\cdot\text{E}_1$ and $-\text{C}=\text{O}\cdot\text{E}_2$, respectively. The substituents carboxyalkyl, carboxyalkenyl, carboxyarylalkyl, and carboxyarylalkenyl may contain 1-4 carboxylic acid functionalities. Examples of the first acyl group include, but are not limited to, succinyl, 2-(C_{1-30} alkyl)succinyl, 2-(C_{2-30} alkenyl)succinyl, maleyl, phthalyl, glutaryl, and itaconyl. Examples of the second acyl group include but are not limited to, acetyl, benzoyl, propionyl, and phenylacetyl.

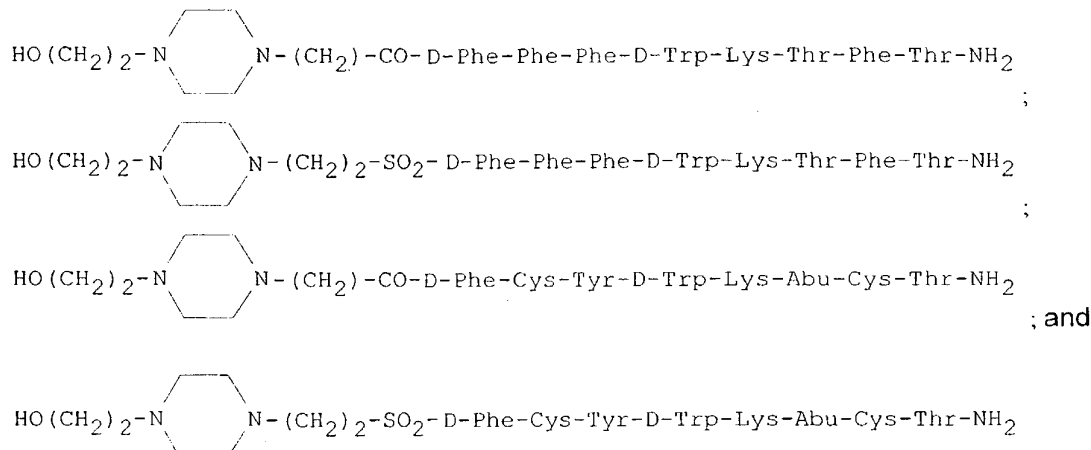
The present invention also features a composition including the above copolymer and a polypeptide, the polypeptide comprising at least one effective ionogenic amine, wherein at least 50 percent, by weight, of the polypeptide present in the composition is ionically bound to the polymer. Preferably, the composition comprises between 5 and 50 percent, by weight, of the polypeptide.

Preferred embodiments of the present invention include a copolymer wherein the first acyl group is succinyl and the second acyl group is acetyl and R_7 is COH or CH_2OH ; a composition comprising said copolymer of claim 1 and H- β -D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr- NH_2 or a pharmaceutically acceptable salt thereof, wherein the two Cys are bonded by a disulfide bond, where at least 50 percent, by weight, of H- β -D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr- NH_2 or a pharmaceutically acceptable salt thereof, present in said composition is ionically bound to said copolymer; a composition comprising the foregoing copolymer and a peptide selected from the group consisting of



or a pharmaceutically acceptable salt thereof, where at least 50 percent, by weight, of said peptide or a pharmaceutically acceptable salt thereof present in said composition is ionically bound to said copolymer; a composition comprising the foregoing copolymer and a peptide selected from the group consisting of (p-Glu-His-Trp-Ser-Tyr-D-Trp-Leu-Arg-Pro-Gly-NH₂), ([D-Ser(t-Bu)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([D-Trp⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([D-Ser(t-Bu)⁶, Azgly¹⁰]-LHRH), ([D-His(Bzl)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([D-Leu⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([D-Trp⁶, MeLeu⁷, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), and ([D-Nal⁶]-LHRH, or a pharmaceutically acceptable salt thereof, where at least 50 percent, by weight, of said peptide or a pharmaceutically acceptable salt thereof, present in said composition is ionically bound to said copolymer; a composition comprising the foregoing copolymer and parathyroid hormone, an analogue thereof or a pharmaceutically acceptable salt thereof, where at least 50 percent, by weight, of parathyroid hormone, an analogue thereof or a pharmaceutically acceptable salt thereof, present in said composition is ionically bound to said copolymer.

Further preferred embodiments of the present invention include a copolymer wherein the first acyl group is glutaryl and the second acyl group is propionyl and R₇ is COH or CH₂OH; a composition comprising the foregoing copolymer and H-β-D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂, wherein the two Cys are bonded by a disulfide bond, where at least 50 percent, by weight, of H-β-D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂, present in said composition is ionically bound to said copolymer; a composition comprising the foregoing copolymer and a peptide selected from the group consisting of



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or a pharmaceutically acceptable salt thereof, where at least 50 percent, by weight, of said peptide or a pharmaceutically acceptable salt thereof present in said composition is ionically bound to said copolymer; a composition comprising the foregoing copolymer and a peptide selected from the group consisting of (p-Glu-His-Trp-Ser-Tyr-D-Trp-Leu-Arg-Pro-Gly-NH₂), ([D-Ser(t-Bu)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([D-Trp⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([D-Ser(t-Bu)⁶, Azgly¹⁰]-LHRH), ([D-His(Bzl)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([D-Leu⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([D-Trp⁶, MeLeu⁷, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), and ([D-Nal⁶]-LHRH, or a pharmaceutically acceptable salt thereof, where at least 50 percent, by weight, of said peptide or a pharmaceutically acceptable salt thereof, present in said composition is ionically bound to said copolymer; and a composition comprising the foregoing copolymer and parathyroid hormone, an analogue thereof or a pharmaceutically acceptable salt thereof, where at least 50 percent, by weight, of parathyroid hormone, an analogue or a pharmaceutically acceptable salt thereof, present in said composition is ionically bound to said copolymer.

Examples of suitable polypeptides include growth hormone releasing peptide (GHRP), luteinizing hormone-releasing hormone (LHRH), somatostatin, bombesin, gastrin releasing peptide (GRP), calcitonin, bradykinin, galanin, melanocyte stimulating hormone (MSH), growth hormone releasing factor (GRF), growth hormone (GH), amylin, tachykinins, secretin, parathyroid hormone (PTH), enkephalin, endothelin, calcitonin gene releasing peptide (CGRP), neuromedins, parathyroid hormone related protein (PTHrP), glucagon, neurotensin, adrenocorticotrophic hormone (ACTH), peptide YY

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(PYY), glucagon releasing peptide (GLP), vasoactive intestinal peptide (VIP), pituitary adenylate cyclase activating peptide (PACAP), motilin, substance P, neuropeptide Y (NPY), TSH and biologically active analogs thereof. The term "biologically active analogs" is used herein to cover naturally occurring, recombinant, and synthetic peptides, polypeptides, and proteins having physiological or therapeutic activity. In general, the term covers all fragments and derivatives of a peptide, protein, or a polypeptide that exhibit a qualitatively similar agonist or antagonist effect to that of the unmodified, or naturally occurring peptide, protein, or polypeptide, e.g., those in which one or more of the amino acid residues occurring in the natural compounds are substituted or deleted, or in which the N- or C- terminal residues has been structurally modified. The term effective ionogenic amine refers to a free amine present on the polypeptide which is capable of forming an ionic bond with the free carboxylic groups on the copolymer.

Examples of other somatostatin analogs include, but are not limited to, the following somatostatin analogs which are disclosed in the above-cited references:

H- β -D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂ acetate salt (also known as SOMATULINE™), where the two Cysteines are bonded by a disulfide bond;

H-D-Phe-Cys-Phe-D-Trp-Lys-Thr-Cys- β -Nal-NH₂;

H-D-Phe-Cys-Tyr-D-Trp-Lys-Thr-Cys- β -Nal-NH₂;

H-D- β -Nal-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

H-D-Phe-Cys-Tyr-D-Trp-Lys-Thr-Pen-Thr-NH₂;

H-D-Phe-Cys-Phe-D-Trp-Lys-Thr-Pen-Thr-NH₂;

H-D-Phe-Cys-Tyr-D-Trp-Lys-Thr-Pen-Thr-OH;

H-D-Phe-Cys-Phe-D-Trp-Lys-Thr-Pen-Thr-OH;

H-Gly-Pen-Phe-D-Trp-Lys-Thr-Cys-Thr-OH;

H-Phe-Pen-Tyr-D-Trp-Lys-Thr-Cys-Thr-OH;

H-Phe-Pen-Phe-D-Trp-Lys-Thr-Pen-Thr-OH;

H-D-Phe-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-ol;

H-D-Phe-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

H-D-Trp-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂;

H-D-Trp-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

H-D-Phe-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂;

H-D-Phe-Cys-Tyr-D-Trp-Lys-Val-Cys-Trp-NH₂;

H-D-Phe-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂;

Ac-D-Phe-Lys*-Tyr-D-Trp-Lys-Val-Asp*-Thr-NH₂ (an amide bridge formed between Lys* and Asp*);

Ac-hArg(Et)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

5 Ac-D-hArg(Et)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

Ac-D-hArg(Bu)-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

Ac-D-hArg(Et)₂-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

Ac-L-hArg(Et)₂-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

Ac-D-hArg(CH₂CF₃)₂-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

10 Ac-D-hArg(CH₂CF₃)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

Ac-D-hArg(CH₂CF₃)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Phe-NH₂;

Ac-D-hArg(CH₂CF₃)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NHEt;

Ac-L-hArg(CH₂CF₃)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

Ac-D-hArg(CH₂CF₃)₂-Gly-Cys-Phe-D-Trp-Lys(Me)-Thr-Cys-Thr-NH₂;

15 Ac-D-hArg(CH₂CF₃)₂-Gly-Cys-Phe-D-Trp-Lys(Me)-Thr-Cys-Thr-NHEt;

Ac-hArg(CH₃, hexyl)-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

H-hArg(hexyl)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

Ac-D-hArg(Et)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NHEt;

Ac-D-hArg(Et)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Phe-NH₂;

20 Propionyl-D-hArg(Et)₂-Gly-Cys-Phe-D-Trp-Lys(iPr)-Thr-Cys-Thr-NH₂;

Ac-D-β-Nal-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Gly-hArg(Et)₂-NH₂;

Ac-D-Lys(iPr)-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

Ac-D-hArg(CH₂CF₃)₂-D-hArg(CH₂CF₃)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

Ac-D-hArg(CH₂CF₃)₂-D-hArg(CH₂CF₃)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Phe-NH₂;

25 Ac-D-hArg(Et)₂-D-hArg(Et)₂-Gly-Cys-Phe-D-Trp-Lys-Thr-Cys-Thr-NH₂;

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H-Bmp-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂;

H-Bmp-Tyr-D-Trp-Lys-Val-Cys-Phe-NH₂;

H-Bmp-Tyr-D-Trp-Lys-Val-Cys-p-Cl-Phe-NH₂;

30 H-Bmp-Tyr-D-Trp-Lys-Val-Cys-β-Nal-NH₂;

H-D-β-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂;

H-D-Phe-Cys-Tyr-D-Trp-Lys-Abu-Cys-Thr-NH₂;

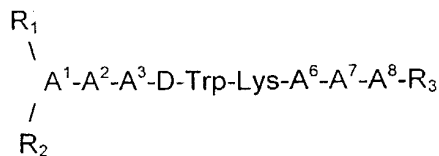
H-D-Phe-Cys-Tyr-D-Trp-Lys-Abu-Cys-β-Nal-NH₂;

- H-pentafluoro-D-Phe-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂;
Ac-D-β-Nal-Cys-pentafluoro-Phe-D-Trp-Lys-Val-Cys-Thr-NH₂;
H-D-β-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-β-Nal-NH₂;
H-D-Phe-Cys-Tyr-D-Trp-Lys-Val-Cys-β-Nal-NH₂;
5 H-D-β-Nal-Cys-Tyr-D-Trp-Lys-Abu-Cys-Thr-NH₂;
H-D-p-Cl-Phe-Cys-Tyr-D-Trp-Lys-Abu-Cys-Thr-NH₂;
Ac-D-p-Cl-Phe-Cys-Tyr-D-Trp-Lys-Abu-Cys-Thr-NH₂;
H-D-Phe-Cys-β-Nal-D-Trp-Lys-Val-Cys-Thr-NH₂;
H-D-Phe-Cys-Tyr-D-Trp-Lys-Cys-Thr-NH₂;
10 cyclo(Pro-Phe-D-Trp-N-Me-Lys-Thr-Phe);
cyclo(Pro-Phe-D-Trp-N-Me-Lys-Thr-Phe);
cyclo(Pro-Phe-D-Trp-Lys-Thr-N-Me-Phe);
cyclo(N-Me-Ala-Tyr-D-Trp-Lys-Thr-Phe);
cyclo(Pro-Tyr-D-Trp-Lys-Thr-Phe);
15 cyclo(Pro-Phe-D-Trp-Lys-Thr-Phe);
cyclo(Pro-Phe-L-Trp-Lys-Thr-Phe);
cyclo(Pro-Phe-D-Trp(F)-Lys-Thr-Phe);
cyclo(Pro-Phe-Trp(F)-Lys-Thr-Phe);
cyclo(Pro-Phe-D-Trp-Lys-Ser-Phe);
20 cyclo(Pro-Phe-D-Trp-Lys-Thr-p-Cl-Phe);
cyclo(D-Ala-N-Me-D-Phe-D-Thr-D-Lys-Trp-D-Phe);
cyclo(D-Ala-N-Me-D-Phe-D-Val-Lys-D-Trp-D-Phe);
cyclo(D-Ala-N-Me-D-Phe-D-Thr-Lys-D-Trp-D-Phe);
cyclo(D-Abu-N-Me-D-Phe-D-Val-Lys-D-Trp-D-Tyr);
25 cyclo(Pro-Tyr-D-Trp-t-4-AchxAla-Thr-Phe);
cyclo(Pro-Phe-D-Trp-t-4-AchxAla-Thr-Phe);
cyclo(N-Me-Ala-Tyr-D-Trp-Lys-Val-Phe);
cyclo(N-Me-Ala-Tyr-D-Trp-t-4-AchxAla-Thr-Phe);
cyclo(Pro-Tyr-D-Trp-4-Amphe-Thr-Phe);
30 cyclo(Pro-Phe-D-Trp-4-Amphe-Thr-Phe);
cyclo(N-Me-Ala-Tyr-D-Trp-4-Amphe-Thr-Phe);
cyclo(Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-Gaba);
cyclo(Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-Gaba-Gaba);

- cyclo(Asn-Phe-D-Trp-Lys-Thr-Phe);
 cyclo(Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-NH(CH₂)₄CO);
 cyclo(Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-β-Ala);
 cyclo(Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-D-Glu)-OH;
 5 cyclo(Phe-Phe-D-Trp-Lys-Thr-Phe);
 cyclo(Phe-Phe-D-Trp-Lys-Thr-Phe-Gly);
 cyclo(Phe-Phe-D-Trp-Lys-Thr-Phe-Gaba);
 cyclo(Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-Gly);
 cyclo(Asn-Phe-Phe-D-Trp(F)-Lys-Thr-Phe-Gaba);
 10 cyclo(Asn-Phe-Phe-D-Trp(NO₂)-Lys-Thr-Phe-Gaba);
 cyclo(Asn-Phe-Phe-Trp(Br)-Lys-Thr-Phe-Gaba);
 cyclo(Asn-Phe-Phe-D-Trp-Lys-Thr-Phe(I)-Gaba);
 cyclo(Asn-Phe-Phe-D-Trp-Lys-Thr-Tyr(But)-Gaba);
 cyclo(Bmp-Lys-Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-Thr-Pro-Cys)-OH;
 15 cyclo(Bmp-Lys-Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-Thr-Pro-Cys)-OH;
 cyclo(Bmp-Lys-Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-Thr-Tpo-Cys)-OH;
 cyclo(Bmp-Lys-Asn-Phe-Phe-D-Trp-Lys-Thr-Phe-Thr-MeLeu-Cys)-OH;
 cyclo(Phe-Phe-D-Trp-Lys-Thr-Phe-Phe-Gaba);
 cyclo(Phe-Phe-D-Trp-Lys-Thr-Phe-D-Phe-Gaba);
 20 cyclo(Phe-Phe-D-Trp(5F)-Lys-Thr-Phe-Phe-Gaba);
 cyclo(Asn-Phe-Phe-D-Trp-Lys(Ac)-Thr-Phe-NH-(CH₂)₃-CO);
 cyclo(Lys-Phe-Phe-D-Trp-Lys-Thr-Phe-Gaba);
 cyclo(Lys-Phe-Phe-D-Trp-Lys-Thr-Phe-Gaba);
 cyclo(Orn-Phe-Phe-D-Trp-Lys-Thr-Phe-Gaba);
 25 H-Cys-Phe-Phe-D-Trp-Lys-Thr-Phe-Cys-NH₂;
 H-Cys-Phe-Phe-D-Trp-Lys-Ser-Phe-Cys-NH₂;
 H-Cys-Phe-Tyr-D-Trp-Lys-Thr-Phe-Cys-NH₂; and
 H-Cys-Phe-Tyr(I)-D-Trp-Lys-Thr-Phe-Cys-NH₂.

30 A disulfide bridge is formed between the two free thiols (e.g., Cys, Pen, or Bmp residues) when they are present in a peptide; however, the disulfide bond is not shown.

Also included are somatostatin agonists of the following formula:



wherein

A¹ is a D- or L- isomer of Ala, Leu, Ile, Val, Nle, Thr, Ser, β-Nal, β-Pal, Trp, Phe, 2,4-dichloro-Phe, pentafluoro-Phe, p-X-Phe, or o-X-Phe, wherein X is CH₃, Cl, Br, F, OH, OCH₃ or NO₂;

A² is Ala, Leu, Ile, Val, Nle, Phe, β-Nal, pyridyl-Ala, Trp, 2,4-dichloro-Phe, pentafluoro-Phe, o-X-Phe, or p-X-Phe, wherein X is CH₃, Cl, Br, F, OH, OCH₃ or NO₂;

A³ is pyridyl-Ala, Trp, Phe, β-Nal, 2,4-dichloro-Phe, pentafluoro-Phe, o-X-Phe, or p-X-Phe, wherein X is CH₃, Cl, Br, F, OH, OCH₃ or NO₂;

A⁶ is Val, Ala, Leu, Ile, Nle, Thr, Abu, or Ser;

A⁷ is Ala, Leu, Ile, Val, Nle, Phe, β-Nal, pyridyl-Ala, Trp, 2,4-dichloro-Phe, pentafluoro-Phe, o-X-Phe, or p-X-Phe, wherein X is CH₃, Cl, Br, F, OH, OCH₃ or NO₂;

A⁸ is a D- or L-isomer of Ala, Leu, Ile, Val, Nle, Thr, Ser, Phe, β-Nal, pyridyl-Ala, Trp, 2,4-dichloro-Phe, pentafluoro-Phe, p-X-Phe, or o-X-Phe, wherein X is CH₃, Cl, Br, F, OH, OCH₃ or NO₂;

each R₁ and R₂, independently, is H, lower acyl or lower alkyl; and R₃ is OH or NH₂; provided that at least one of A¹ and A⁸ and one of A² and A⁷ must be an aromatic amino acid; and further provided that A¹, A², A⁷ and A⁸ cannot all be aromatic amino acids.

Examples of linear agonists to be used in a process of this invention include:

H-D-Phe-p-chloro-Phe-Tyr-D-Trp-Lys-Thr-Phe-Thr-NH₂;

H-D-Phe-p-NO₂-Phe-Tyr-D-Trp-Lys-Val-Phe-Thr-NH₂;

H-D-Nal-p-chloro-Phe-Tyr-D-Trp-Lys-Val-Phe-Thr-NH₂;

H-D-Phe-Phe-Phe-D-Trp-Lys-Thr-Phe-Thr-NH₂;

H-D-Phe-Phe-Tyr-D-Trp-Lys-Val-Phe-Thr-NH₂;

H-D-Phe-p-chloro-Phe-Tyr-D-Trp-Lys-Val-Phe-Thr-NH₂; and

H-D-Phe-Ala-Tyr-D-Trp-Lys-Val-Ala-β-D-Nal-NH₂.

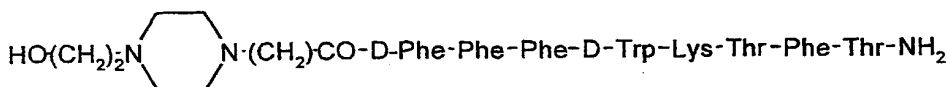
If desired, one or more chemical moieties, e.g., a sugar derivative, mono or poly-hydroxy C₂₋₁₂ alkyl, mono or poly-hydroxy C₂₋₁₂ acyl groups, or a piperazine derivative, can be attached to the somatostatin agonist, e.g., to the N-terminus amino acid. See

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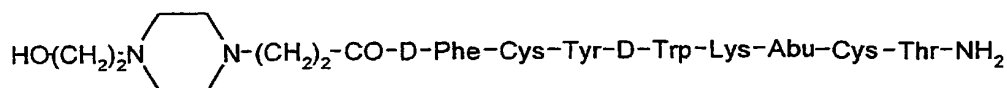
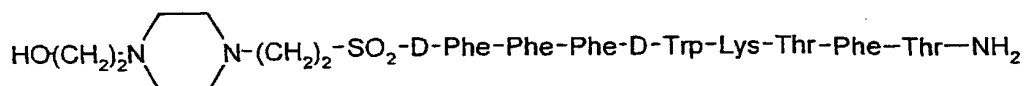
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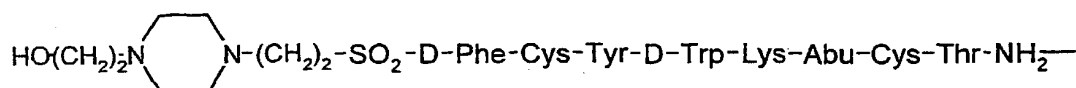
PCT Application 88/02756, European Application 0 329 295, and PCT Application No. WO 95/04752. An example of somatostatin agonists which contain N-terminal chemical substitutions are:



5



; and



or a pharmaceutically acceptable salt thereof.

10

Examples of specific LHRH analogues that can be incorporated in a conjugate or composition of this invention are TRYPTORELIN™ (p-Glu-His-Trp-Ser-Tyr-D-Trp-Leu-Arg-Pro-Gly-NH₂), busarelin ([D-Ser(t-Bu)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), deslorelin ([D-Trp⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), fertirelin ([des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), gosreltin ([D-Ser(t-Bu)⁶, Azgly¹⁰]-LHRH), histrelin ([D-His(Bzl)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), leuporelin (D-Leu⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), lutrelin ([D-Trp⁶, MeLeu⁷, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), nafarelin ([D-Nal⁶]-LHRH) and pharmaceutically acceptable salts thereof.

15

The release of the polypeptide from the composition may be modified by changing the chemical structure of the composition. Increasing the molecular weight of the polymer will decrease the rate of peptide released from the conjugate. Increasing the number of carboxylic acid groups on the polymer will increase the amount of polypeptide ionically bound to the composition, and consequently, increase the amount of release of the peptide from the conjugate.

20

The release of the polypeptide may be further modulated through (a) treating the composition with soluble salts of divalent or polyvalent metallic ions of weak acids (e.g., calcium, iron, magnesium, or zinc); (b) coating the particles with a thin, absorbable layer made of a glycolide copolymer or silicone oil in a spherical, cylindrical or planar

25

configuration; or (c) microencapsulating the composition in an absorbable glycolide copolymer. In one embodiment, the composition comprises between 0.01 and 20 percent, by weight, of a polyvalent metal.

Depending on the choice of polypeptide, the compositions can be used to treat any number of disorders. For example, somatostatin, bombesin, GRP, LHRH, and analogs thereof, have been shown to treat various forms of cancer. Growth factors such as GH, GRF, and GHRP, and analogs thereof, have been shown to stimulate growth in both adolescents and the elderly. Calcitonin, amylin, PTH, and PTHrP, and analogs thereof, have been shown to treat osteoporosis and other bone disorders.

The compositions are designed for parenteral administration, e.g., intramuscular, subcutaneous, intradural, or intraperitoneal injection. Preferably, the compositions are administered intramuscularly.

The compositions of the invention can be in the form of powder or a microparticle to be administered as a suspension with a pharmaceutically acceptable vehicle (e.g., water with or without a carrier substance such as mannitol or polysorbate). The compositions may also be compounded in the form of a rod for parenteral implantation using a trocar, e.g., intramuscular implantation.

The dose of the composition of the present invention for treating the above-mentioned diseases or disorders varies depending upon the manner of administration, the age and the body weight of the subject, and the condition of the subject to be treated, and ultimately will be decided by the attending physician or veterinarian. Such an amount of the composition as determined by the attending physician or veterinarian is referred to herein as a "therapeutically effective amount."

In another aspect, the present invention features a process of synthesizing a copolymer, the process comprising the steps of: reacting chitosan with a weak acid to produce a lower molecular weight polysaccharide; reacting between 1 and 50 percent of the free amines of the lower molecular weight polysaccharide with a first acylating agent, the first acylating agent selected from the group consisting of C₄-C₃₄ polycarboxyalkane, C₄-C₃₄ polycarboxyalkene, C₈-C₄₀ polycarboxyarylalkane, C₁₀-C₄₀ polycarboxyarylalkene, or an acylating derivative thereof; and reacting between 50 and 100 percent of the free amine of the lower molecular weight polysaccharide with a second acylating agent, the second acylating agent selected from the group consisting of C₂₋₃₁ monocarboxyalkane, C₃₋₃₁ monocarboxyalkene, C₇₋₃₈ monocarboxyarylalkane, C₉₋₃₅ monocarboxyarylalkene, or an acylating derivative thereof. The reaction of the

lower molecular weight polysaccharide with both the first acylating agent and the second acylating agent may be measured with an amine detecting agent (e.g., fluorescamine) to ensure that between 1 and 50 percent of the free amines of the lower molecular weight polysaccharide are acylated with the first acylating agent and between
5 50 and 99 percent of the free amines of the lower molecular weight polysaccharide are acylated with the second acylating agent. See, e.g., Bailey, P.D., An Introduction to Peptide Chemistry (Wiley, NY)(1990); Oppenheimer, H, et al. Archives Biochem. Biophys. 120:108-118 (1967); Stein, S, Arch. Biochem. Biophys. 155:203-212 (1973).

Reacting chitosan with the weak acid (e.g., nitrous acid) cleaves the polymer,
10 thereby reducing its molecular weight (e.g., 2,500 - 80,000 daltons). In preferred embodiments, the first acylating group and the second acylating agent are reacted with the lower molecular weight polysaccharide successively, e.g., either the first acylating agent is reacted before the second acylating agent is reacted or the second acylating agent is reacted before the first acylating agent or simultaneously. As a result of the
15 acylation of the free amines, some of the free hydroxy groups of the lower molecular weight polysaccharide may be acylated. The extent of the acylation of the free hydroxy groups may be altered by changing the pH or the solvents or agents used during the acylation reactions, or the acylating agents used.

Examples of acylating derivatives include, but are not limited to, anhydrides and
20 N-acylated heterocycles (e.g., imidazoles and pyrazoles). See e.g., Bodansky, et al., The Practice of Peptide Synthesis, 87-150 (Springer-Verlag, 1984). The agents polycarboxyalkane, polycarboxyalkene, polycarboxyarylalkane, and polycarboxyarylalkene or acylating derivatives thereof contain, or originate from reactants containing, 2-5 carboxylic acid functionalities. The substituents
25 monocarboxyalkane, monocarboxyalkene, monocarboxyarylalkane, and monocarboxyarylalkene contain, or originate from reactants containing, only a single carboxylic acid group. Examples of first acylating agents include, but are not limited to, succinic anhydride, 2-(C₁₋₃₀ alkyl)succinic anhydride, 2-(C₂₋₃₀ alkenyl)succinic anhydride, maleic anhydride, glutaric anhydride, itaconic anhydride, and phthalic anhydride.
30 Examples of second acylating agents include, but are not limited to, acetic anhydride, benzoic anhydride, N,N'-diacetyl-3,5-dimethylpyrazole, N,N'-diacetylimidazole, phenylacetic anhydride, propionic anhydride, and butyric anhydride.

In yet another aspect, the present invention features a process of synthesizing a composition, the process comprising the steps of: reacting chitosan with a weak acid to produce a lower molecular weight polysaccharide; reacting between 1 and 50 percent of the free amines of the lower molecular weight polysaccharide with a first acylating agent, the first acylating agent selected from the group consisting of C₄-C₃₄ polycarboxyalkane, C₄-C₃₄ polycarboxyalkene, C₈-C₄₀ polycarboxyarylalkane, C₁₀-C₄₀ polycarboxyarylalkene, or an acylating derivative thereof; reacting between 50 and 100 percent of the free amine of the lower molecular weight polysaccharide with a second acylating agent, the second acylating agent selected from the group consisting of C₂-C₃₁ monocarboxyalkane, C₃-C₃₁ monocarboxyalkene, C₇-C₃₈ monocarboxyarylalkane, C₉-C₃₅ monocarboxyarylalkene, or an acylating derivative thereof; neutralizing the acylated lower molecular weight polysaccharide with a base; and mixing the neutralized lower acylated molecular weight polysaccharide with a polypeptide salt, wherein the polypeptide salt comprises at least one ionogenic amine, to form a polypeptide-copolymer ionic conjugate.

The neutralization step preferably renders the lower molecular weight polysaccharide emulsifiable or soluble in water. In preferred embodiments, the base is an inorganic base (e.g., sodium hydroxide). The polypeptide salt is preferably a weak acid salt (e.g., acetate, lactate, or citrate). The ionic conjugate can be isolated by filtering or by centrifuging the resulting mixture.

The conjugates of the invention can easily be made into injectable microspheres or microparticles, and implantable films or rods, without the need to utilize processing that entails multiphase emulsions. Preferably, the microparticles are manufactured by (a) dissolving the composition in an aprotic, water miscible organic solvent; (b) mixing the organic solvent in water; and (c) isolating the microparticles from the water. In preferred embodiments, the organic solvent is chosen from the group of acetone, acetonitrile, tetrahydrofuran, dimethylformamide, and dimethyl ethylene glycol.

Other features and advantages of the present invention will be apparent from the detailed description and from the claims.

Detailed Description of the Invention

The synthesis and use of the copolymer and copolymer-polypeptide ionic conjugates of this invention are well within the ability of a person of ordinary skill in the art. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this

invention belongs. Also, all publications, patent applications, patents, and other references mentioned herein are incorporated by reference.

It is believed that one skilled in the art can, based on the description herein, utilize the present invention to its fullest extent. The following specific embodiments are, therefore, to be construed as merely illustrative, and not limitative of the remainder of the disclosure in any way whatsoever.

Example 1: Depolymerization of Chitosan

Chitosan (Protan, Inc., Portsmouth, NH) is dissolved in aqueous acetic acid by stirring with a mechanical stirrer for one day. Nitrogen gas is bubbled through the solution, while an aqueous solution of sodium nitrite is added. After a half hour, the solution is filtered through a sintered glass funnel, under reduced pressure, to remove insoluble particles which are present in the initial chitosan solution. To the filtered solution is added an aqueous solution of NaOH, and the solution is vigorously stirred in methanol to precipitate the polymer. The resulting precipitate is then filtered and alternately washed five times with water and methanol. The precipitate is then dried in a vacuum oven at 60°C for two days. The depolymerized chitosan comprises an aldehyde group at one end of the chain. The aldehyde end group may be reduced to a primary hydroxyl group by reaction NaBH₄. The depolymerized product can be analyzed by gel permeation chromatography (GPC) to determine both its molecular weight and molecular weight distribution (MWD) in comparison to Pullulan reference standards. NMR (nuclear magnetic resonance) and IR (infra-red) studies can be used to determine the amount of N-acetylation on the depolymerized product.

Example 2: Partial Succinylation of Depolymerized Chitosan

The depolymerized chitosan from Example 1 is dissolved in 0.1M aqueous acetic acid. To this solution, methanol is added followed by the addition of a solution of succinic anhydride in acetone. The resulting solution is stirred at room temperature for 24 hours. Upon completion of the succinylation, the solution is then precipitated into aqueous acetone. The resulting precipitate is collected by centrifugation and washed five times with methanol. The precipitate is then dissolved in 0.5M KOH and dialyzed against water to a pH of 7. The dialyzed solution is then concentrated under reduced pressure, precipitated in aqueous acetone, and dried in a vacuum oven at 60°C.

To obtain variable levels of succinylation, the extent of the reaction can be monitored as the acylation proceeds by analyzing for number of unacylated amine

groups. The number of unacylated amine groups can be determined by quenching a withdrawn sample of the reaction mixture with an amine detecting agent (e.g., fluooreescamine). The amount of amine present can be measured spectrophoretically using a standard curve for the copolymer. Additionally, succinic anhydride, thus, can be added successively until the desired acylation percentage is achieved. The exact degree of succinylation of the purified product can be determined using ^1H NMR spectroscopy and conductometric titration.

Example 3: Acetylation of the N-succinylated chitosan

The partial succinylated sample from Example 2 is dissolved in 0.1M aqueous acetic acid. To this solution, methanol and acetic anhydride is then added, and the reaction mixture is stirred at room temperature for one day. This solution is then precipitated in aqueous acetone. The resulting precipitate is collected by centrifugation and washed five times with methanol. The precipitate is then dissolved in 0.1N KOH and is dialyzed against water to a pH of 7. The final solution is lyophilized to obtain the final product. The acylation procedure can be measured spectrophoretically as discussed in Example 2, and the exact degree of acylation of the purified product can be determined using ^1H NMR spectroscopy and conductometric titration.

Example 4: Preparation of poly(N-acyl-D-glucosamine)-peptide ionic conjugate

The N-succinylated chitosan potassium salt of Example 3 is dissolved in water. An aqueous solution of the acetate salt of the somatostatin polypeptide analog SOMATULINE™ (D-Nal-c[Cys-Tyr-D-Trp-Lys-Val-Cys]-Thr-NH₂; Kinerton, Dublin, Ireland) is added to the stirred polymer solution. A precipitate forms and is filtered and dried in a vacuum oven at 40°C.

The polypeptide content of the resulting ionic conjugate can be determined by the difference between the amount of initial peptide added and the amount of free residual peptide contained in the filtrate and rinse solution. The peptide content of the resulting ionic conjugate can be determined by comparing the carbon/nitrogen ratio of the initial N-succinylated chitosan with that of the resulting ionic conjugate. GPC analysis can be used to determine molecular weight and MWD, differential scanning calorimetry (DSC) to determine thermal properties and NMR and IR for chemical identity.

Example 5: Homogeneous Depolymerization of Chitosan

Chitosan (Aldrich, Sigma-Aldrich Co. Ltd., Gillingham, Dorset, England, high molecular weight, 10g) was dissolved in 1L of 0.1M aqueous acetic acid (acetic acid, min. 99.8%, Riedel-de Haën, article number 33209) in a 2L glass beaker with stirring at about 144 rpm using a Heidolph mechanical stirrer (model RZR 2102, Kelheim, Germany). Dissolution was complete within ~4 hours. The inherent viscosity, η_{inh} , of the final depolymerized chitosan was shown to be dependent on the concentration of sodium nitrite and the time given for depolymerization, t_{depol} , (Table 1). Inherent viscosity, η_{inh} , was determined using a Cannon-Fenske routine Ubbelodhe viscometer (Poulten Selfe & Lee Ltd., number 50 of constant 0.003890(mm²/s)/s at 40°C) with 0.1M acetic acid as solution.

Table 1

NaNO ₂ (g)	T _{depolym} (min)	Yield (%)	η_{inh} (DL/g)
0.76	35	90.8	1.52
0.76	45	87.6	0.98
0.76	55	85.1	0.65
0.152	30	76.7	0.33
0.304	30	22.0	0.23
0.304	90	No ppt.	-

Sodium nitrite (Aldrich, Sigma-Aldrich Co. Ltd., Gillingham, Dorset, England) in 5-20ml de-ionized (DI) water (depending on the mass) was added to the solution. After the required depolymerization time, the solution was filtered as quickly as possible through a sintered glass funnel (25-50 μ , Ace Glass Incorporated, Vineland, N.J.) to remove insoluble matter. To the filtered solution was added NaOH (Aldrich) in DI water (ranging from 4.5g in 100ml to 20g in 400ml) to quench the depolymerizing action of NaNO₂. Solution was then added to vigorously stirred methanol (Labscan, HPLC grade, 300ml) to precipitate the polymer. Suspension was spun at 4,000rpm at 4°C for 35min using a Sorvall RC 5B plus centrifuge. After spinning, the supernatant was decanted off and precipitate was washed with a water/methanol (Labscan, AR grade) mixture (1L, 80:20). Suspension was centrifuged as before, supernatant was again decanted off and depolymerized chitosan was lyophilised in an Edwards Super Modulyo lyophiliser for two days following overnight refrigeration. The depolymerized chitosan was further dried for 1 day in a vacuum oven (Bioblock Scientific, Strasbourg, -22mmHg at 30°C).

Example 6: Heterogeneous Depolymerization

Chitosan (18.0g, as before) and NaNO_2 (as before) were added to a 1L glass beaker. Trifluoroacetic acid solution (Riedel-de Haën, 23ml in 600ml DI water, 0.5M) was added to the beaker and the mixture was stirred using a Heidolph mechanical stirrer (as before). Considerable fizzing was observed on addition of the TFA solution. The solution was filtered on a sintered glass funnel (as before). NaOH solution (13.3g in 165ml DI water) was added to the filtered solution. The resulting solution was then added to vigorously stirred methanol (Labscan, HPLC grade, 300ml). Centrifugation and washing was carried out as per homogeneous depolymerization. Table 2 gives results from a series of depolymerization experiments.

Table 2

NaNO_2 (g)	T_{depolym} (min)	Yield (%)	η_{inh} (DL/g)
9.0	15	24.0	0.19
9.0	23	20.9	0.13
9.0	45	16.3	0.11
4.5	15	69.5	0.30

With the heterogeneous method, dissolution and depolymerization take place simultaneously making it a faster method. Both methods gave similar yields (Table 1; 0.33DL/g with a yield of 76.7% and 0.30DL/g with a yield of 69.1%) but with the heterogeneous method larger quantities of chitosan can be used; 18g as opposed to 10g. The dried depolymerized chitosan samples (from examples 5 and 6) with inherent viscosity values in the range 0.23-1.51DL/g were analysed by ^{13}C NMR in aqueous CD_3COOD using a Bruker Spectrospin 400 NMR spectrometer. Chemical shifts of carbons C_1 to C_6 are given in Table 3. The chemical shift of a particular carbon increases with the inherent viscosity.

Table 3

C Type	Shift (ppm)
C_1	96.12-99.30
C_2	54.58-57.44
C_3	75.20-78.69
C_4	73.55-76.41
C_5	68.90-71.80
C_6	58.74-61.77

Elemental analysis was carried out on the depolymerized chitosan samples from examples 5 and 6 (Table 4).

Table 4

Series of Depolymerized Chitosan samples	η_{inh} (DL/g)	% Nitrogen
	0.11	3.07
	0.13	3.50
	0.19	3.40
	0.30	5.42
	0.33	5.87
	0.98	6.78
Low mol. Wt. Chitosan	8.76	7.11
High mol. Wt. Chitosan	48.50	7.42

The amino content, that is the fraction of chitosan repeating units containing amino groups was obtained by a metachromatic titration using acid red 88 (Aldrich, dye content ~75%) by following the method outlined by Gummow and Roberts (Beryl. D. Gummow, George A.F. Roberts, Makromol. Chem. 186, 1239-1244 (1985), the contents of which are incorporated herein). Amino content values are given in Table 5.

Table 5

η_{inh} (DL/g)	Amino Content
48.9 (Aldrich High mol. wt. Chitosan)	0.83
8.76 (Aldrich Low mol. wt. Chitosan)	0.78
0.98	0.74
0.30	0.56

From % nitrogen values and the amino content values of a series of depolymerized chitosan samples in Tables 4 and 5, it is evident that a decrease in η_{inh} is accompanied by a decrease in the amino content indicating deamination with depolymerization.

Calculations For Glutarylation/Propionylations:

The masses of glutaric and propionic anhydrides required for a glutarylation/propionylation reaction are dependent on the desired molar ratio between the two anhydrides, the mass and amino content of depolymerized chitosan used. General equations for the masses of anhydrides for stoichiometric glutarylation/propionylation are given here:

Mass of Glutaric Anhydride (GA) required= Desired GA Fraction x Mass Chitosan x
Amino Content x 114.1* /161**

*F.W. (GA)

**161 = F.W. repeating unit of Chitosan

5 Mass of Propionic Anhydride (PA) required= Desired PA Fraction x Mass Chitosan x
Amino Content x 130.14*** /161

***F.W. (PA)

Example 7A: Glutarylation/Propionylation of Depolymerized Chitosan

Depolymerized chitosan from example 5 with an inherent viscosity of 1.51DL/g
10 was dissolved in 0.1M acetic acid (4.01g in 150ml). The amino content of this sample
was not known at the time but it can be assumed that it is between 0.74 for
depolymerized chitosan of inherent viscosity 0.98DL/g and 0.78 for low mol. wt. chitosan
from Aldrich (Table 5). Glutaric anhydride (Aldrich, 95%, 6.0g) and propionic anhydride
15 (Aldrich, 99+%m, 6.0g) with glutaric anhydride at an approximately 5.7 fold excess and
propionic anhydride at an approximately 5.0 fold excess in acetone (Labscan, Dublin,
Ireland, AR grade, 29.9ml, 23.62g) solution were added to the chitosan solution and left
stirring overnight. Resulting solution which was gel-like in nature was poured into
acetone (Labscan, AR grade, 200ml) to induce precipitation. Dispersion was spun at
20 4000rpm at about 4°C for about 25min. After spinning, supernatant was washed with
methanol (Labscan, HPLC grade, 600ml) and spun as before. Supernatant was
decanted off and product was lyophilized following overnight refrigeration. Because of
the high excess of anhydride used, the lyophilized product was washed by redissolving
in 0.2M NaOH solution, filtering to remove insoluble matter and precipitation in methanol
25 (Labscan, HPLC grade, 300ml). After spinning at 4000rpm at about 4°C for about
25min, supernatant was decanted off and the product was dried by lyophilization (2
days) and vacuum dried for 1 day. % Nitrogen in the final product as determined by
elemental analysis was 3.92%.

Example 7B: Glutarylation/Propionylation of Depolymerized Chitosan

Depolymerized chitosan from example 5 with an inherent viscosity of 0.98DL/g
30 was dissolved in 0.1M acetic acid (1.23g in 46ml). The amino content of this sample was
calculated to be 0.74 (Table 5). Glutaric anhydride (Aldrich, 95%, 1.33g) and propionic
anhydride (Aldrich, 99+%m 1.33g) with glutaric anhydride at an approximately 3.8 fold
excess and propionic anhydride at an approximately 3.3 fold excess in acetone
(Labscan, AR grade, 10.1ml, 8g) solution was added to the chitosan solution and left

stirring overnight. Resulting solution was poured into acetone (Labscan, AR grade, 80ml) to induce precipitation. Dispersion was spun at 4000rpm at about 4°C for about 25min. After spinning, supernatant was washed with methanol (Labscan, HPLC grade, 600ml) and spun as before. Supernatant was decanted off and product was lyophilized following overnight refrigeration and then vacuum oven dried (1 day). % Nitrogen of this product as determined from elemental analysis was 5.11%.

Example 7C: Glutarylation/Propionylation of Depolymerized Chitosan

Depolymerized chitosan from example 5 with an inherent viscosity of 0.98DL/g was dissolved in 0.1M acetic acid (4.02g in 150ml). The amino content of this sample was calculated to be 0.74 (Table 5). Glutaric anhydride (Aldrich, 95%, 4.01g) and propionic anhydride (Aldrich, 99+% 4.05g) with glutaric anhydride at an approximately 3.8 fold excess and propionic anhydride at an approximately 3.3 fold excess in acetone (Labscan, AR grade, 29.4ml, 23.2g) solution was added to the chitosan solution and left stirring overnight. Resulting solution was poured into acetone (Labscan, AR grade, 200ml) to induce precipitation. Dispersion was spun at 4000rpm at about 4°C for about 25min. After spinning, supernatant was washed with methanol (Labscan, HPLC grade, 600ml) and spun as before. Supernatant was decanted off and product was lyophilized following overnight refrigeration. Because of the high excess of anhydride used, the lyophilized product was washed by redissolving in 0.2M NaOH solution, filtering to remove insoluble matter and precipitation in methanol (Labscan, HPLC grade, 300ml). After spinning at 4000rpm at about 4°C for about 25min, supernatant was decanted off and the product was dried by lyophilization (2 days) and vacuum dried for 1 day. % Nitrogen of this product as determined from elemental analysis was 5.11%.

Example 7D: Glutarylation/Propionylation of Depolymerized Chitosan

Depolymerized chitosan from example 6 with an inherent viscosity of 0.30DL/g was dissolved in 0.1M acetic acid (4.01g in 150ml). The amino content of this sample was calculated to be 0.56. Glutaric anhydride (Aldrich, 95%, 3.0g) and propionic anhydride (Aldrich, 99+%, 1.0g) in acetone (Labscan, Dublin, Ireland, AR grade, 29.9ml, 23.6g) solution was added to the chitosan solution and left stirring overnight. Resulting solution was poured into acetone (Labscan, AR grade, 200ml) to induce precipitation. Dispersion was spun at 4000rpm at about 4°C for about 25min. After spinning, supernatant was washed with methanol (Labscan, HPLC grade, 600ml) and spun as before. Supernatant was decanted off and product was lyophilized for 2 days

following overnight refrigeration and vacuum dried for 1 day. % Nitrogen of this product as determined from elemental analysis was 5.29%.

Glutarylation/Propionylation – A Kinetic Study

6.51 grams of chitosan from example 5 of inherent viscosity, 0.98DL/g and amino content of 0.74 were dissolved in 0.1M aqueous acetic acid (225ml). A molar ratio of propionic anhydride to glutaric anhydride of 4 was desired in the final product. Glutaric anhydride (Aldrich, 95%, 1.443g) was dissolved in methanol (10ml) (Labscan, Dublin, Ireland, HPLC grade) and the solution was added to the chitosan solution with stirring at room temperature. After about 2 hours, a 40ml aliquot of the reaction mixture was precipitated in acetone (Labscan, Dublin, Ireland, A.R. grade) spun at 2900rpm at about 4°C for about 25min. Precipitate was washed with methanol (Labscan, HPLC grade) and dried. Another 40ml aliquot was taken after 4 hours, precipitated, washed and dried as before. Immediately after the 40ml aliquot was taken (4 hours), propionic anhydride solution (Aldrich, 99+%, 2.6489g in methanol (Labscan, HPLC grade, 10ml)) was added to the reaction mixture. After a further 2 hours reaction (equivalent to a total reaction time of 6 hours from the addition of the glutaric anhydride solution), the entire mixture was precipitated in acetone (Labscan, AR grade, 330ml), dispersion was spun at 4000rpm at about 4°C for about 30min in a Sorvall RC plus centrifuge. After spinning, supernatant was decanted off and cake was washed twice with methanol (Labscan, HPLC grade, 400ml), lyophilized and vacuum oven dried. A metachromatic titration as mentioned in examples 5 and 6 was carried out on the three modified chitosan samples taken at 2 hours, 4 hours and finally 6 hours. The amino content of these three samples is given in Table 6.

Table 6

Time (hours)	Amino Content
2	0.91
4	0.43
6	0.10

Example 8A: Preparation of Poly(N-propionylated, N-glutaryl原因, N-acetylated-D-glucosamine)-Peptide Ionic Conjugate

1.0038 grams of product from example 7A was dissolved in 20ml 0.2M NaOH solution. 450μl of acetic acid was added to the glutaryl原因/propionylated solution to

bring the pH down to ~6. Modified chitosan solution was then added slowly to a solution of 122.9mg of H- β -D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂ acetate salt (also known as SOMATULINE™), where the two Cysteines are bonded by a disulfide bond (Kinerton Ltd., Blanchardstown, Dublin, Ireland, B/N 93K2505DL3, Acetate =12.37%, potency = 82.68%) in 3.73g DI water and precipitation was observed. The precipitate is also known as a conjugate of the polymer and drug. Dispersion was spun at 2900rpm at about 4°C for about 25min using a Sorvall RT 6000 centrifuge. Supernatant was decanted off and retained for further manipulation. Precipitate was placed in a refrigerator. Acetic acid was added to the retained supernatant until the pH fell to ~4. Further precipitation ensued. Dispersion was spun as before and then stored in fridge. Precipitate from first and second centrifuges were lyophilized, vacuum oven dried and yields obtained were respectively 31.7% (356.9mg) and 36.4% (409.6mg) with a combined yield of 68.1%. Elemental analysis was carried out on the combined product. % Nitrogen as determined from elemental analysis for the combined conjugate was 4.60% and using the % nitrogen of 3.92% for product from example 7A, the % loading of SOMATULINE™ was calculated to be 6.7%.

In vivo assay: Conjugate of example 8A was suspended in saline containing Tween® 20 (1%) and injected at 7.5mg peptide equivalent per rat. SOMATULINE™ levels in rat plasma induced by this conjugate were between a maximum value of 636,757+/-124,759 pg/ml and a minimum value of 863+/-145pg/ml over a 15 day period, see Table 7.

Example 8B: Preparation of Poly(N-propionylated, N-glutaryl原因, N-acetylated-D-glucosamine)-Peptide Ionic Conjugate

1.0010 grams of product from example 7A was dissolved in 12ml 0.2M NaOH solution. 250 μ l of acetic acid was added to the glutaryl原因/propionylated solution to bring the pH down to ~6. Modified chitosan solution was then added slowly to a solution of 120.3mg of SOMATULINE™ (Kinerton Ltd., Blanchardstown, Dublin, Ireland, B/N 93K2505DL3, Acetate =12.37%, potency = 82.68%) in 2.87g DI water and precipitation was observed. Because of the lower volume of NaOH solution used, the resulting solution was extremely viscous. Dispersion was spun at 2900rpm at about 4°C for about 25min using a Sorvall RT 6000 centrifuge. Supernatant was decanted off and retained for further manipulation. Precipitate was placed in a refrigerator. Acetic acid was added to the retained supernatant until the pH fell to ~4. Further precipitation ensued.

Dispersion was spun as before and then stored in a refrigerator. Precipitate from first and second centrifuges were lyophilized, vacuum oven dried and yields obtained were respectively 53.5% (600.4mg) and 20.9% (234.8mg) with a combined yield of 74.4%. Elemental analysis was carried out on the combined product. % Nitrogen as determined from elemental analysis for the combined conjugate was 4.30% and using the % nitrogen of 3.92% for product from example 7A, the % loading of SOMATULINE™ was calculated to be 4.0%.

In vivo assay: Conjugate was suspended in saline containing Tween® 20 (1%) and injected at 7.5mg peptide equivalent per rat. SOMATULINE™ levels in rat plasma induced by this conjugate were between a maximum value of 545,367+/-69,445 pg/ml and a minimum value of 1134+/-325pg/ml over a 15 day period, see Table 7.

Example 8C: Preparation of Poly(N-propionylated, N-glutarylated, N-acetylated-D-glucosamine)-Peptide Ionic Conjugate

1.0190 grams of example 7B was dissolved in 20ml 0.2M NaOH solution. 200µl of acetic acid was added to the glutarylated/propionylated solution to bring the pH down to ~6. Modified chitosan solution was then added slowly to a solution of 102.1mg of SOMATULINE™ (Kinerton Ltd., Blanchardstown, Dublin, Ireland, B/N 93K2505DL3, Acetate =12.37%, potency = 82.68%) in 2.56g DI water and precipitation was observed. Dispersion was spun at 2900rpm at about 4°C for about 25min using a Sorvall RT 6000 centrifuge. Supernatant was decanted off and retained for further manipulation. Precipitate was placed in refrigerator. Acetic acid was added to the retained supernatant until the pH fell to ~4. Further precipitation ensued. Dispersion was spun as before and then stored in a refrigerator. Precipitate from first and second centrifuges were lyophilized, vacuum oven dried and the combined yield obtained was 74% (827.1mg). % Loading of SOMATULINE™ in this conjugate was taken to be similar to the % Loading of SOMATULINE™ example 4D i.e., 14%.

In vivo assay: Conjugate was suspended in saline containing Tween® 20 (1%) and injected at 7.5mg peptide equivalent per rat. SOMATULINE™ levels in rat plasma induced by this conjugate were between a maximum value of 168,141+/- 90,972 pg/ml and a minimum value of 1000pg/ml over a 9 day period, see Table 7.

Example 8D: Preparation of Poly(N-propionylated, N-glutarylated, N-acetylated-D-glucosamine)-Peptide Ionic Conjugate

1.0149 grams of example 7C was dissolved in 15ml 0.05M NaOH solution. The molarity of the NaOH in this example is lower than that of example 8C. 200 μ l of acetic acid was added to the glutarylated/propionylated solution to bring the pH down to ~6. Modified chitosan solution was then added slowly to a solution of 125.2mg of SOMATULINE™ (Kinerton Ltd., Blanchardstown, Dublin, Ireland, B/N 93K2505DL3, Acetate =9.37%, potency = 80.68%) in 3.0g DI water and precipitation was observed. Dispersion was spun at 2900rpm at about 4°C for about 25min using a Sorvall RT 6000 centrifuge. Supernatant was decanted off and retained for further manipulation. Precipitate was placed in fridge. Acetic acid was added to the retained supernatant until the pH fell to ~4. Further precipitation ensued. Dispersion was spun as before and then stored in fridge. Precipitate from first and second centrifuges were lyophilized, vacuum oven dried and the combined yield obtained was only 24% (270mg). Elemental analysis was carried out on the combined product. % Nitrogen as determined from elemental analysis for the combined conjugate was 6.34% and using the % nitrogen of 5.11% for product from example 7C, the % loading of SOMATULINE™ was calculated to be 14.0%.

In vivo assay: Conjugate was suspended in saline containing Tween® 20 (1%) and injected at 7.5mg peptide equivalent per rat. SOMATULINE™ levels in rat plasma induced by this conjugate were between a maximum value of 192,419+/-112,621 pg/ml and a minimum value of 1000/ml over a 12 day period, see Table 7.

Example 8E: Preparation of Poly(N-propionylated, N-glutarylated, N-acetylated-D-glucosamine)-Peptide Ionic Conjugate

2.0 grams of example 7D was dissolved in 28ml 0.05M NaOH solution. Chitosan solution was then added slowly to a solution of 246.0mg of SOMATULINE™ (Kinerton Ltd., Blanchardstown, Dublin, Ireland, B/N 93K2505DL3, Acetate =9.37%, potency = 80.68%) in 6.0g DI water and precipitation was observed. Dispersion was spun at 2900rpm at about 4°C for about 25min using a Sorvall RT 6000 centrifuge. Supernatant was decanted off. Precipitate was washed with 24ml DI water and spun as before. Precipitate was then placed in a refrigerator. Elemental analysis was carried out on the product. % Nitrogen as determined from elemental analysis for the conjugate was 6.6%

and using the % nitrogen of 5.29% for product from example 7D, the % loading of SOMATULINE™ was calculated to be 15%.

In vivo assay: Conjugate was suspended in saline containing Tween® 20 (1%) and injected at 3.75mg peptide equivalent per rat. SOMATULINE™ levels in rat plasma induced by this conjugate were between a maximum value of 145,429±122,743pg/ml and a minimum value of 500±159/ml over a 10 day period, see Table 7.

Other Embodiments

It is to be understood that while the invention has been described in conjunction with the detailed description thereof, that the foregoing description is intended to illustrate and not limit the scope of the invention, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the claims.

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CLAIMS

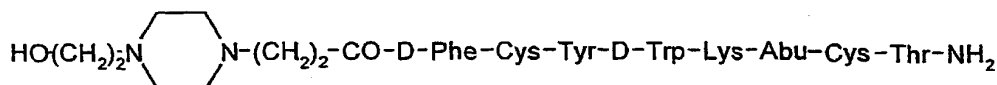
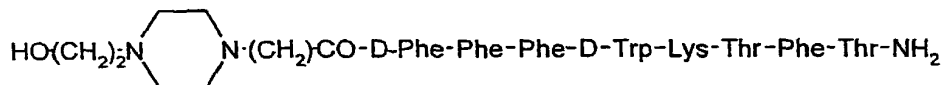
What is claimed is:

1. A copolymer comprising an N-acylated derivative of poly(2-amino-2-deoxy-D-glucose), wherein between 1 and 50 percent of the free amines of said poly(2-amino-2-deoxy-D-glucose) are acylated with glutaryl
5 and between 50 and 99 percent of the free amines of said poly(2-amino-2-deoxy-D-glucose) are acylated with propionyl and a terminal monomer of said N-acylated derivative of poly(2-amino-2-deoxy-D-glucose) contains COH or CH₂OH.
- 10 2. A composition comprising a copolymer and a peptide, wherein said copolymer comprises an N-acylated derivative of poly(2-amino-2-deoxy-D-glucose) having between 1 and 50 percent of the free amines of said poly(2-amino-2-deoxy-D-glucose) acylated with succinyl, between 50 and 99 percent of the free amines of said poly(2-amino-2-deoxy-D-glucose) acylated
15 with acetyl provided that at least one of the free amines of said poly(2-amino-2-deoxy-D-glucose) is acylated with succinyl, and a terminal monomer of said N-acylated derivative of poly(2-amino-2-deoxy-D-glucose) containing COH or CH₂OH, and wherein said peptide comprises H-β-D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂ or a pharmaceutically acceptable salt thereof, having the
20 two Cys of said peptide bonded by a disulfide bond and at least 50 percent by weight, of the H-β-D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂ peptide, or a pharmaceutically acceptable salt thereof, present in said composition ionically bound to said copolymer.
- 25 3. A composition comprising said copolymer of claim 2 and a peptide wherein said peptide is selected from the group consisting of

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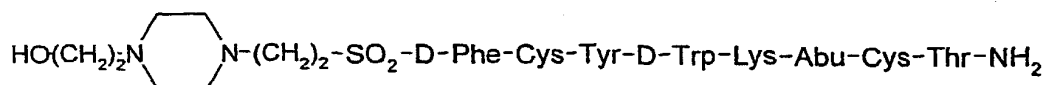
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; and

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or a pharmaceutically acceptable salt thereof, having at least 50 percent, by weight, of said peptide, or a pharmaceutically acceptable salt thereof, present in said composition, ionically bound to said copolymer.

4. A composition comprising said copolymer of claim 2 and a peptide wherein said peptide is selected from the group consisting of (p-Glu-His-Trp-Ser-Tyr-D-Trp-Leu-Arg-Pro-Gly-NH₂), ([D-Ser(t-Bu)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([D-Trp⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([D-Ser(t-Bu)⁶, Azgly¹⁰]-LHRH), ([D-His(Bzl)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), (D-Leu⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([D-Trp⁶, MeLeu⁷, des-Gly-NH₂¹⁰]-LHRH(1-9)NH₂), ([D-Nal⁶]-LHRH) or a pharmaceutically acceptable salt thereof, wherein at least 50 percent, by weight, of said peptide, or a pharmaceutically acceptable salt thereof, present in said composition is ionically bound to said copolymer.

5. A composition comprising said copolymer of claim 1 and H-β-D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂, wherein the two Cys are bonded by a disulfide bond and at least 50 percent, by weight, of H-β-D-Nal-Cys-Tyr-D-Trp-Lys-Val-Cys-Thr-NH₂, present in said composition is ionically bound to said copolymer.

6. A composition comprising said copolymer of claim 1 and a peptide selected from the group consisting of

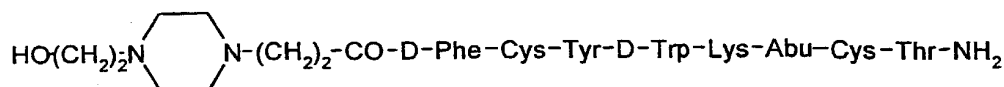
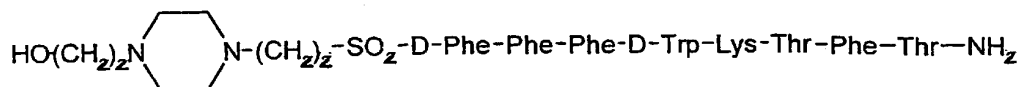
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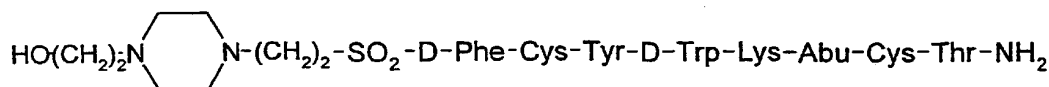


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or a pharmaceutically acceptable salt thereof, wherein at least 50 percent, by weight, of said peptide or a pharmaceutically acceptable salt thereof present in said composition is ionically bound to said copolymer.

7. A composition comprising said copolymer of claim 1 and a peptide selected from the group consisting of (p-Glu-His-Trp-Ser-Tyr-D-Trp-Leu-Arg-Pro-Gly-NH₂), ([D-Ser(t-Bu)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([D-Trp⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([D-Ser(t-Bu)⁶, Azgly¹⁰]-LHRH), ([D-His(Bzl)⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), (D-Leu⁶, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([D-Trp⁶, MeLeu⁷, des-Gly-NH₂¹⁰]-LHRH(1-9)NHet), ([D-Nal⁶]-LHRH) or a pharmaceutically acceptable salts thereof, wherein at least 50 percent, by weight, of said peptide or a pharmaceutically acceptable salt thereof, present in said composition is ionically bound to said copolymer.

8. A composition comprising said copolymer of claim 2 and parathyroid hormone, an analogue thereof, or a pharmaceutically acceptable salt thereof, wherein at least 50 percent, by weight, of said parathyroid hormone, an analogue thereof, or a pharmaceutically acceptable salt thereof, present in said composition is ionically bound to said copolymer.

9. A composition comprising said copolymer of claim 1 and parathyroid hormone, an analogue thereof, or a pharmaceutically acceptable salt thereof, wherein at least 50 percent, by weight, of said parathyroid

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hormone, an analogue thereof, or a pharmaceutically acceptable salt thereof,
present in said composition is ionically bound to said copolymer.

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(21) International Application Number: PCT/US99/23406 (22) International Filing Date: 8 October 1999 (08.10.99) (30) Priority Data: 09/169,423 9 October 1998 (09.10.98) US (63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application US 09/169,423 (CON) Filed on 9 October 1998 (09.10.98) (71) Applicant (for all designated States except US): SOCIETE DE CONSEILS DE RECHERCHES ET D'APPLICATIONS SCIENTIFIQUES S.A. [FR/FR]; 51-53, rue du Docteur Blanche, F-75016 Paris (FR). (72) Inventors; and (75) Inventors/Applicants (for US only): SHALABY, Shalaby, W. [US/US]; P.O. Box 814, Pendleton, SC 29670 (US). JACKSON, Steven, A. [US/US]; 81 North Mill Street, Holliston, MA 01746 (US). IGNATIUS, Francis, X. [IN/US]; 15 Eagle Rock Drive, Millville, MA 01529 (US). MOREAU, Jacques-Pierre [US/US]; 159 Westboro Road,		Upton, MA 01568 (US). RUSSELL, Ruth, M. [IE/IE]; 40 Westpark Drive, Finglas, Dublin 11 (IE). (74) Agent: TSAO, Y., Rocky; Fish & Richardson P.C., 225 Franklin Street, Boston, MA 02110-2804 (US). (81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: IONIC MOLECULAR CONJUGATES OF N-ACYLATED DERIVATIVES OF POLY(2-AMINO-2-DEOXY-D-GLUCOSE) AND POLYPEPTIDES		
(57) Abstract <p>A copolymer comprising an N-acylated derivative, and a composition comprising said copolymer and a polypeptide, said polypeptide comprising at least one effective ionogenic amine, wherein at least 50 percent, by weight, of said polypeptide present in said composition is ionically bound to said polymer.</p>		

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled IONIC MOLECULAR CONJUGATES OF N-ACYLATED DERIVATIVES OF POLY(2-AMINO-2-DEOXY-D-GLUCOSE) AND POLYPEPTIDES, the specification of which:

☐ is attached hereto.

☒ was filed on April 9, 2001 as Application Serial No. 09/807,087 and was amended on

☒ was described and claimed in PCT International Application No. PCT/US99/23406 filed on December 8, 1999 and as amended under PCT Article 19 on

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim the benefit under Title 35, United States Code, §119(e)(1) of any United States provisional application(s) listed below:

U.S. Serial No.	Filing Date	Status
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I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose all information I know to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. Serial No.	Filing Date	Status
09/169,423	October 9 1998	Pending

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

Country	Application No.	Filing Date	Priority Claimed
			<input type="checkbox"/> Yes <input type="checkbox"/> No
			<input type="checkbox"/> Yes <input type="checkbox"/> No

Combined Declaration and Power of Attorney

Page 2 of 3 Pages

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

(6) Y. Rocky Tsao, Reg. No. 34,053; Brian R. Morrill Reg. No. 42,098; Alan F. Feeney Reg. No. 43,609; Timothy A. French, Reg. No. 30,175; Eric L. Prahl, Reg. No. 32,590; and Frank R. Occhuiti, Reg. No. 35,306.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

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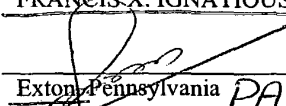
Attorney's Docket No.: 00537-111004

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